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No. 42

A Dollar's Worth of Condensed Information

Jigs and Fixtures

By EINAR MORIN

PART II

DRILL JIGS

SECOND EDITION

Price 25 Cents

CONTENTS

Design of Open Drill Jigs - - - - - - 3
Examples of Open Drill Jigs - - - - - 13
Design of Closed or Box Jigs - - - - - - 22
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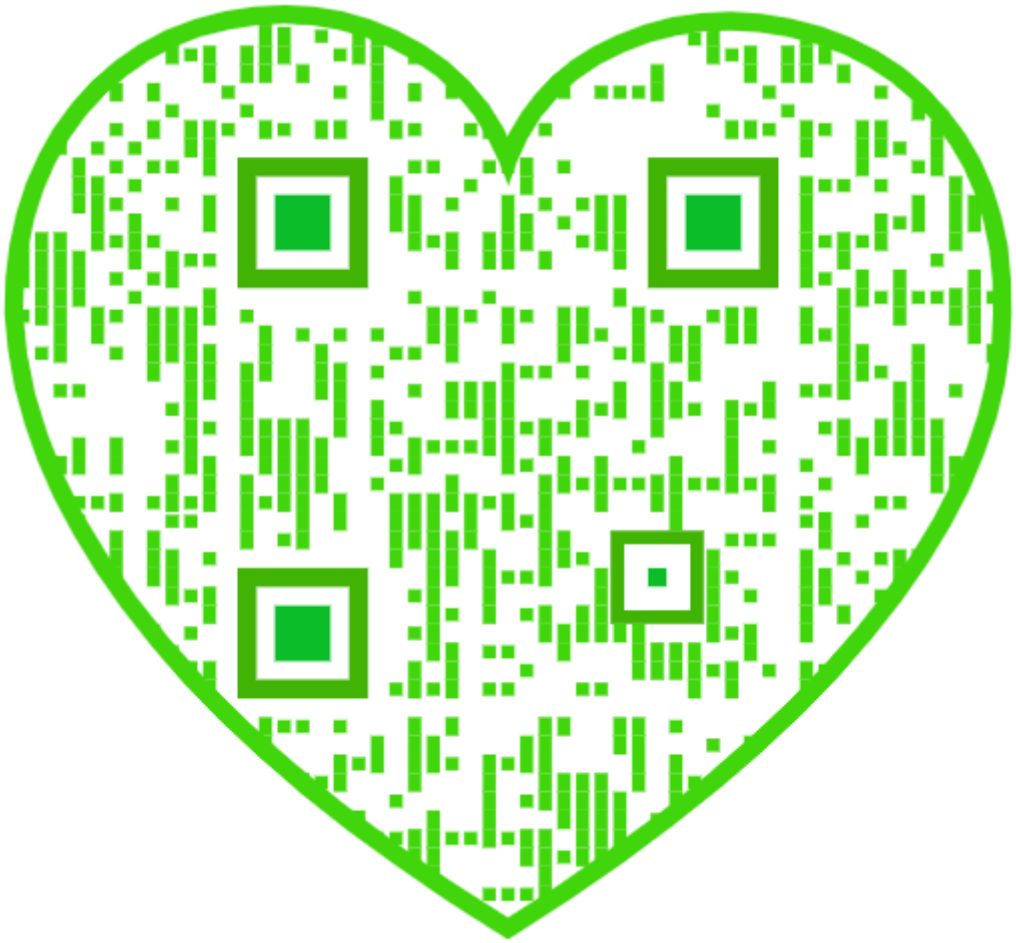

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JIGS AND FIXTURES—PART II

CHAPTER V

DESIGN OF OPEN DRILL JIGS*

To give any rational rules or methods for the design of drill jigs would be almost impossible, as almost every jig must be designed in a somewhat different way from every other jig, to suit and conform to the requirements of the work. All that can be done is to lay down the principles. The main principles for jigs as well as fixtures were treated at length in Chapter I. It is proposed in the following to dwell more in detail on the carrying out of the actual work of designing jigs.

Before making any attempt to put the lay-out of the jig on paper, the designer should carefully consider what the jig will be required to do, the limits of accuracy, etc., and to form, in his imagination, a certain idea of the kind of a jig that would be suitable for the purpose. In doing so, if a model or sample of the work to be made is at hand, it will be found to be a great help to study the actual model. If the drawing, as is most often the case, is the only thing that is at hand, then the outline of the work should be drawn in red ink on the drawing paper, on which the jig is subsequently to be laid out, and the jig built up, so to speak, around this outline. The designing of the jig will be greatly simplified by doing this, as the relation between the work and the jig will always be plainly before the eyes of the designer, and it will be more easily decided where the locating points and clamping arrangements may be properly placed. When drawing and projecting the different views of the jig on the paper, the red outline of the work will not in any way interfere, and when the jig is made from the drawing, the red lines are simply ignored, except to the extent to which the outline of the pieces may help the tool-maker to understand the drawing and the purpose of certain locating points and clamping devices.

If it is possible, the jig should be drawn full size, as it is a great deal easier to get the correct proportions, when so doing. Of course, in many cases, it will be impossible to draw the jigs full size. In such cases the only thing to do is to draw them to the largest possible regular scale. Every jig draftsman should be supplied with a set of blue-prints containing dimensions of standard screws, bolts, nuts, thumb-screws, washers, wing nuts, sliding points, drills, counterbores, reamers, bushings, etc.; in short, with blue-prints giving dimensions of all parts that are used in the construction of jigs, and

* MACHINERY, August and September, 1908.

which are, or can be, standardized. It should be required of every designer and draftsman that he use these standards to the largest possible extent, so as to bring the cost of jigs down to as low a figure as possible.

If it does not meet with objections from higher authorities, which it ought not to, it is highly advantageous for the obtaining of best results, that, before starting on the drawing, the draftsman who is to lay out the jig should converse with the foreman who is actually going to use the jig. Oftentimes this man will be able to supply the best idea for the making of the jig or tool. Not only is advantage taken of the combined experience of the draftsman and the foreman, but it is also a precaution of great importance for making all parties feel satisfied.

As a jig drawing, in most cases, is only used once, or at most only a very few times, it is not considered worth while to make a tracing or blue-print from the drawing, but, as a rule, the pencil drawing itself may be used to advantage. If, however, it is given out in the shop directly as it comes from the drawing-board, it is likely to get soiled, and to be used in such a manner that, after a while, it would be impossible to make out the meaning of the views shown on it. For this reason, in the first place, jig drawings should be made on heavy paper, preferably of brown color, which is not as quickly soiled as white paper. In order to prevent the drawing being torn, it should be mounted on strawboard, and held down along the edges by thin wooden strips, nailed to the board. It is also desirable to cover the drawings with a thin coat of shellac before they are sent out in the shop. When this is done, the dirt and black spots which will be always found on the drawing when it stays in the shop, if only for a few hours, may be washed off directly; and the shellac itself may be washed off by wood alcohol, when the drawing is returned to the drafting-room. The drawing, after having been cleaned, is then detached from the strawboard, which may be used over and over again. The drawing is, of course, filed away according to the drafting-room system. The most advantageous sizes for jig drawings for medium to heavy work are as follows:

Full size sheet, $40 \times 27\frac{1}{2}$ inches.
Half size sheet, $27\frac{1}{2} \times 20$ inches.
Quarter size sheet, $20 \times 13\frac{3}{4}$ inches.
Eighth size sheet, $13\frac{3}{4} \times 10$ inches.

Of course, these sizes will vary in different shops, and in many cases, particularly when the tool designing department and the regular drafting-room are combined as one drafting department, the jig drawings should be of the same regular sizes as the ordinary machine drawings.

It is common in a great many shops to make no detailed drawings of jigs, but simply to draw a sufficient number of different views and sections, and to dimension the different parts directly on the assembly drawings. In cases where the jig drawings are extremely complicated, and where they are covered with a large number of dimensions which

make it hard to read the drawing and to see the outlines of the jig body itself, it has proved a great help to trace the outlines of the jig body, and of such portions as are made of cast iron, on tracing paper, omitting all loose parts, and simply putting on the necessary dimensions for making the patterns. A blue-print is then made from this paper tracing, and this is sent to the pattern-maker, who will find the drawing less of a puzzle, and who will need to spend far less time to understand how the pattern actually looks. A less skilled, and consequently a cheaper, man may also be used for making the pattern. It is, however, greatly to be doubted whether it is good policy not to detail jig drawings completely, the same as other machine details.

When jigs are made up for pieces of work which require a great many operations to be carried out with the same jig, and where a great number of different bushings, different sizes of drills, reamers, counterbores, etc., are used, a special operation sheet should be provided which should be delivered to the man using the jig, together with the jig itself. This enables him to use the jig to best advantage. On this sheet should be marked the order in which the various operations are to be performed, and the tools and bushings which are to be used. Of course, the bushings in such a case should be numbered or marked in some way so as to facilitate the selection of the correct bushing for the particular tool with which it is used. If this system is put in force and used for simpler classes of jigs also, the operator will need few or no instructions from his foreman, outside of this operation sheet.

The Designing of Open Jigs

The present chapter will be devoted to explaining and illustrating the application of the principles previously outlined, to the simplest and most common design of drill jig—the open jig. We will assume that the drill jig is to be designed for a piece of work, as shown in Fig. 61. Consideration must first be given to the size of the piece, to the finish given to the piece previous to the drilling operation, the accuracy required as regards the relation of one hole to the other, and in regard to the surfaces of the piece itself. The number of duplicate pieces to be drilled must also be considered, and, in some cases, the material.

The very simplest kind of drill jig that could be used for the case taken as an example would be the one illustrated in Fig. 62, which simply consists of a flat plate of uniform thickness of the same outline as the piece to be drilled, and provided with holes for guiding the drill. Such a jig would be termed a jig plate. For small pieces, the jig plate would be made of machine steel and case-hardened, or from tool steel and hardened. For larger work, a machine steel plate can also be used, but in order to avoid the difficulties which naturally would arise from hardening a large plate, the holes are simply bored larger than the required size of drill, and are provided with lining bushings to guide the drill, as shown in Fig. 63. It would not be

necessary, however, to have the jig plate made out of steel for large work, as a cast-iron plate provided with tool steel or machine steel guiding bushings would answer the purpose just as well, and at the same time be much cheaper, and almost as durable. The thickness of the jig plate varies according to the size of the holes to be drilled and the size of the plate itself.

The holes in the jig in Fig. 62 and in the bushings in the jig in Fig. 63, are made the same size as the size of the hole to be drilled in the work, with proper clearance for the cutting tools. If the size and location of the holes to be drilled are not of great consequence, it is sufficient to simply drill through the work with a full size drill guided by the jig plate, but when a nice, smooth, standard size hole is required, the holes in the work must be reamed. The hole is first spotted by a spotting drill, which is of exactly the same size as the reamer used for finishing, and which fits the hole in the jig plate or bushing nicely. Then a so-called reamer drill, which is 0.010 inch, or less, smaller in diameter than the reamer, is put through, leaving only a slight amount of stock for the reamer to remove, thereby obtaining a very satisfactory hole. Sometimes a separate loose bushing is used for each one of these operations, but this is expensive and also unnecessary, as the method described gives equally good results.

By using the rose reaming method very good results will also be obtained. In this case two loose bushings besides the lining bushing will be used. These bushings were described and tabulated in Chapter II. The drill preceding the rose chucking reamer is 1/16 inch smaller than the size of the hole. This drill is first put through the work, a loose drill bushing made of steel being used for guiding the drill. Then the rose chucking reamer is employed, using, if the hole in the jig be large, a loose bushing made of cast iron.

When dimensioning the jig on the drawing, dimensions should always be given from two finished surfaces of the jig to the center of the holes, or at least to the more important ones. In regard to the holes, it is not sufficient to give only the right angle dimensions, *a*, *b*, *c*, and *d*, etc., Fig. 62, but the radii between the various holes must also be given. If there are more than two holes, the radii should always be given between the nearest holes and also between the holes standing in a certain relation to one another, as, for instance, between centers of shafts carrying meshing gears, sprockets, etc. This will prove a great help to the tool-maker. In the case under consideration, the dimensions ought to be given from two finished sides of the work to the centers of the holes, and also the dimension between the centers of the holes to be drilled.

When using a simple jig, made as outlined in Figs. 62 and 63, this jig is simply laid down flat on the work and held against it by a C-clamp, a wooden clamp, or, if convenient, held right on the drill press table by means of a strap or clamp, as shown in Fig. 64. Here two pieces of the work are shown beneath the jig plate, both being drilled at one time.

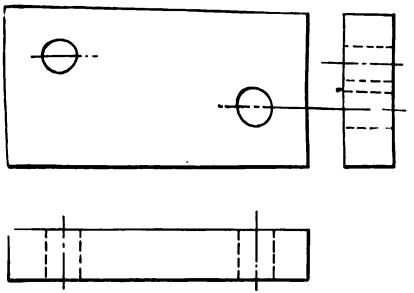


Fig. 61. Sketch of Plate to be Drilled

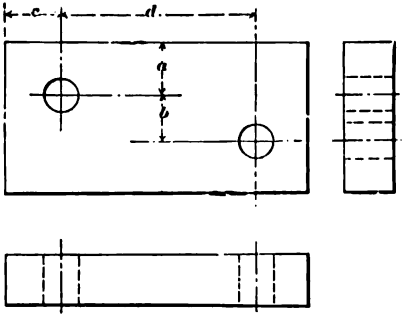


Fig. 62. Simplest Form of Jig for Piece shown in Fig. 61

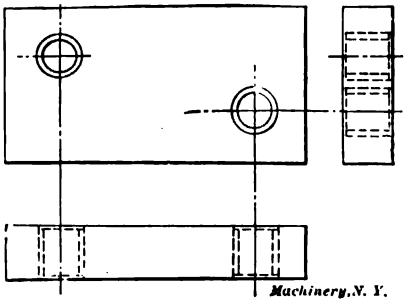


Fig. 63. Plate Jig with Inserted Guide Bushings

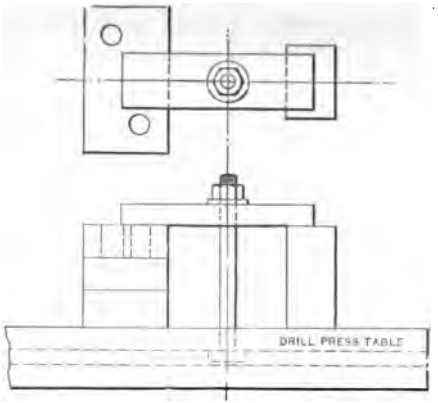


Fig. 64. Holding Jig and Work on Drill Press Table. Two Pieces Drilled at Once

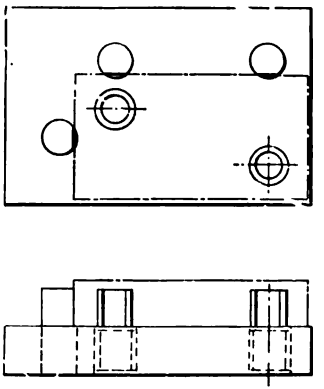


Fig. 65. First Improvement on Plate Jig: Locating Pins Inserted

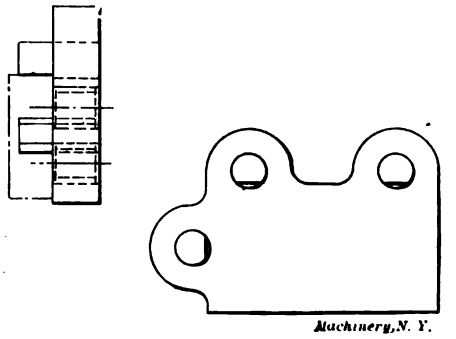


Fig. 66. Variation in Shape of Plate Jig

Improving the Simple Form of Jig Shown in Fig. 63

The first improvement that could be made on the jig shown in Fig. 63 would be the placing of locating points in the jig plate in the form of pins, as shown in Fig. 65, in which the dotted lines represent the outline of the work. The plate need not necessarily have the shape shown in Fig. 65, but may have the appearance shown in Fig. 66, according to the conditions. As previously mentioned in this chapter, exact rules could not be given for the form and shape of jigs, but common sense together with the judgment obtained by long practice must be relied upon in determining the minor points of design.

The adding of the locating points will, of course, increase the cost of the jig somewhat, but the amount of time saved in using the jig will undoubtedly make up for the added expense of the jig, provided a fair number of pieces is to be drilled; besides, a great advantage is gained in that the holes can always be placed in the same relation

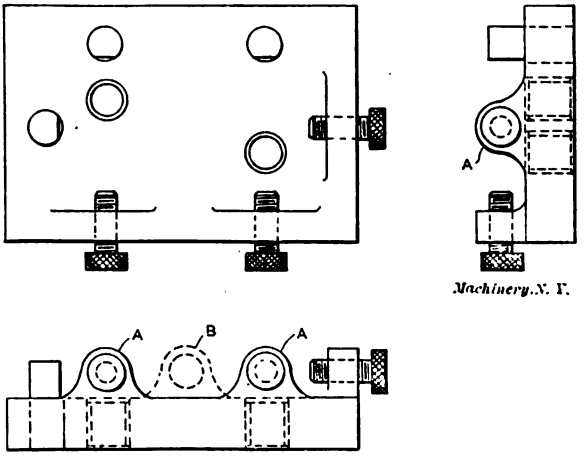


Fig. 67. Second Improvement: Locating Screws Holding Work in Place

to the two sides resting against the locating pins on all the pieces drilled. The locating pins are flattened off to a depth of 1/16 inch from the outside circumference, and dimensions should be given from the flat to the center of the pin holes and to the center of the nearest or the most important of the holes to be drilled in the jig. The same strapping or clamping arrangements for the jig and work, as mentioned for the simpler form of jig, may be employed.

Improving the Jig by Adding Locating Screws

The next step toward improving the jig under consideration would be to provide the jig with locating screws, as shown in Fig. 67. By the addition of these, the locating arrangements of the jig become complete, and the piece of work will be prevented from shifting or moving sideways. These locating screws should be placed in accordance with Rule 10 laid down in the summary of the principles of jig

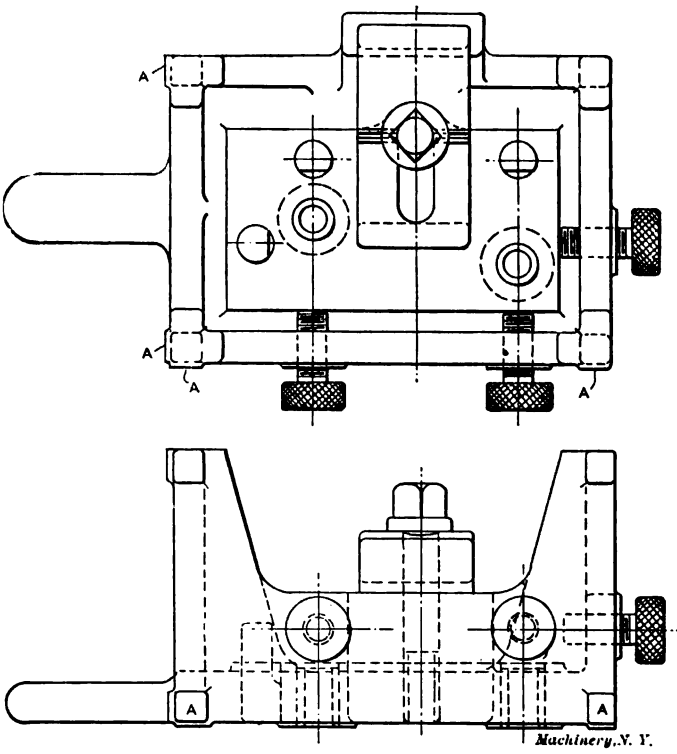
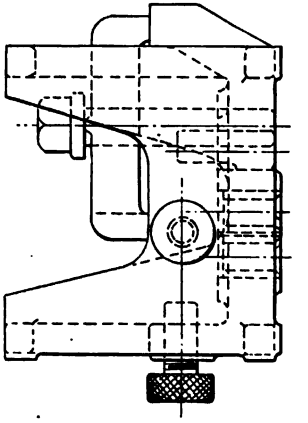


Fig. 68. Complete Jig for Rapid Duplicate Work



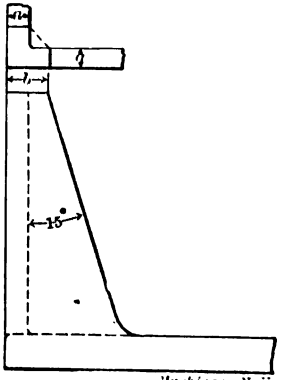


Fig. 69. Design of Legs for Cast-iron Jig Bodies

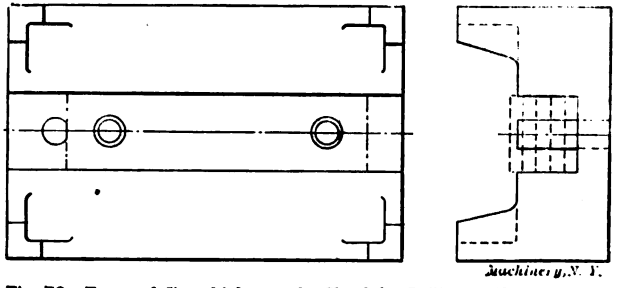


Fig. 70. Form of Jig which may be Used for Drilling a Number of Pieces Simultaneously

design in Chapter I, saying that all clamping points should be located as nearly opposite to some bearing points of the work as possible. In order to provide for locating set-screws in our present jig, three lugs or projections *A* are added which hold the set-screws. If possible the set-screw lugs should not reach above the surface of the piece of work, which should rest on the drill press table when drilling the holes.

The present case illustrates the difficulty of giving exact rules for jig design and indicates the necessity of individual judgment. It is perfectly proper to have two set-screws on the long side of the work, but in a case like this where the piece is comparatively short and stiff, one lug and set-screw, as indicated by the dotted lines at *B* in Fig. 67, would be fully sufficient. The strain of the set-screw placed right between the two locating pins will not be great enough to spring

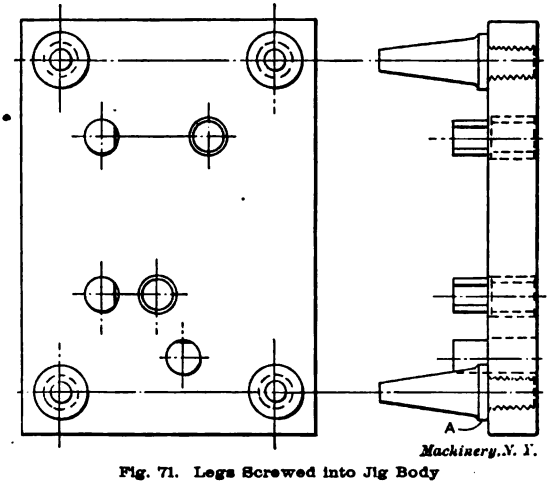


Fig. 71. Legs Screwed into Jig Body

the piece out of shape. When the work is long and narrow, two set-screws are required on the long side, but whenever a saving in cost can be obtained without sacrificing efficiency, as in the case illustrated, two lugs would be considered a wasteful design.

Providing Clamps and Feet for the Jig

The means by which we have so far clamped or strapped the work to the jig when drilling in the drill press (see Fig. 64) have not been integral parts of the jig. If we wish to add clamping arrangements that are integral parts of the jig, the next improvement would be to add four legs in order to raise the jig plate enough above the surface of the drill press table to get the required space for such clamping arrangements. The completed jig of the best design for rapid manipulation and duplicate work would then have the appearance shown in Fig. 68. The jig here is provided with a handle cast integral with the jig body, and with a clamping strap which can be pulled back for

removing and inserting the work. Instead of having the legs solid with the jig, as shown in Fig. 68, loose legs, screwed in place, are sometimes used, as shown in Fig. 71.

These legs are round, and provided with a shoulder *A*, preventing them from screwing into the jig plate. A headless screw or pin through the edge of the circumference of the threads at the top prevents the studs from becoming loose. These loose legs are usually made of machine steel or tool steel, the bottom end being hardened and then ground and lapped, so that all the four legs are of the same length. It is the practice of many tool-makers not to thread the legs into the jig body, but simply to provide a plain surface on the end of the leg, which enters into the jig plate, and is driven into place. This is much easier, and there is no reason why for almost all kinds of work, jigs provided with legs attached in this manner should not be equally durable.

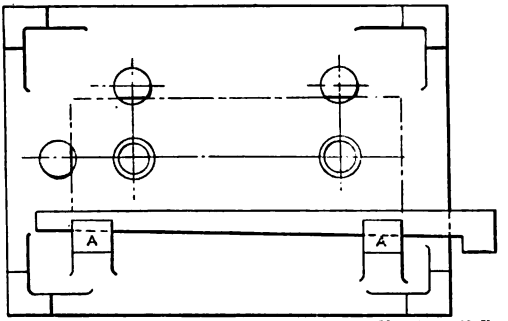
Of course, when jigs are made of machine or tool steel, and legs are required, the only way to provide them is to insert loose legs. In the case of cast-iron jigs, however, solid legs cast in place are preferable. The solid legs cast in place generally have the appearance shown in Fig. 69. The two webs of the leg form a right angle, which, for all practical purposes, makes the leg fully as strong as if it were made solid, as indicated by the dotted line in the upper view. The side of the leg is tapered 15 degrees, as a rule, as shown in the engraving, but this may be varied according to conditions. The thickness of the leg varies according to the size of the jig, the weight of the work, and the pressure of the cutting tools, and depends also upon the length of the leg. The length *b* on top is generally made 1½ times *a*. As an indication of the size of the legs required, it may be said that for smaller jigs, up to jigs with a face area of 6 square inches, the dimension *a* may be made from 5/16 to 3/8 inch; for medium sized jigs, ½ to ⅝ inch; for larger sized jigs, ¾ to 1½ inch; but of course, these dimensions are simply indications of the required dimensions. As to the length of the legs, the governing condition, evidently, is that they must be long enough to reach below the lowest part of the work and the clamping arrangement.

If a drill is to be used in a multiple spindle drill, it should be designed a great deal stronger than it is ordinarily designed when used for drilling one hole at a time. This is especially true if there is a large number of holes to drill simultaneously. The writer has had sad experiences with drill jigs which would give excellent service in common drill presses for years, but which, when put on a multiple spindle drill, immediately broke to pieces as if subjected to a hammer-blow. It is evident that the pressure upon the jig in a multiple spindle drill is as many times greater than the pressure in a common drill press as the number of drills in operation at once.

Referring again to Fig. 68, attention should be called to the small lugs *A* on the sides of the jig body which are cast in place for laying out and planing purposes. The handle should be made about 4 inches long, which permits a fairly good grip by the hand. The design of

the jig shown in Fig. 68 is simple, and fills all requirements necessary for producing work quickly and accurately. At the same time, it is strongly and rigidly designed. Locating points of a different kind from those shown can, of course, be used; and the requirements may be such that adjustable locating points, as described in Chapter III, may be required. A more quick acting, but at the same time, a far more complicated clamping arrangement might be used, but the question is whether the added increase in the rapidity of manipulation offsets the expense thus incurred.

Another improvement which should not be overlooked, and which in a case like this probably could be made, and which it is always wise to look into at any rate is: Can more than one piece be drilled at one time? In the present case, the locating pins can be made longer, or, if there is a locating wall, it can be made higher, the legs of the jig can be made longer, and the screw holding the clamp can also



Machinery, N. Y.

Fig. 72. Jig with Wedge for Holding the Work

be increased in length; if the pieces of work are thick enough, set-screws for holding the work against the locating pins can be placed in a vertical line, or if the pieces be narrow, they can be placed diagonally, so as to gain space. If the pieces are very thin, the locating might be a more difficult proposition. If they are made of a uniform width, they could simply be put in the slot in the bottom of the jig, as shown in Fig. 70, or if a jig on the principles of the one shown in Fig. 68, is used, they might be located sideways by a wedge, as shown in Fig. 72. A couple of lugs *A* would then be added to hold the wedge in place, and take the thrust. In both cases the pieces must be pushed up in place endways by hand. If the pieces are not of exactly uniform size, and it is desired to drill a number at a time, they must be pushed up against the locating pins by hand from two sides, and the clamping strap must be depended upon to clamp them down against the pressure of the cut, and at the same time prevent them from moving side or endwise. If the accuracy of the location of the holes is important, but one piece at a time should be drilled.

CHAPTER VI

EXAMPLES OF OPEN DRILL JIGS*

A typical example of an open drill jig, very similar to the one developed and explained in the previous chapter, is shown in Fig. 73. The work is located against the three locating pins *A*, and held in place against these pins by the three set-screws *B*. The three straps *C* hold the work securely against the finished pad, in the bottom of the jig. These clamps are so placed that when the work has been drilled and the clamp screws loosened, the clamps will swing around a quarter of a turn, allowing the work to be lifted directly from the jig and a new piece of work inserted; then the clamps are again turned around into the clamping position, and the screws tightened. These

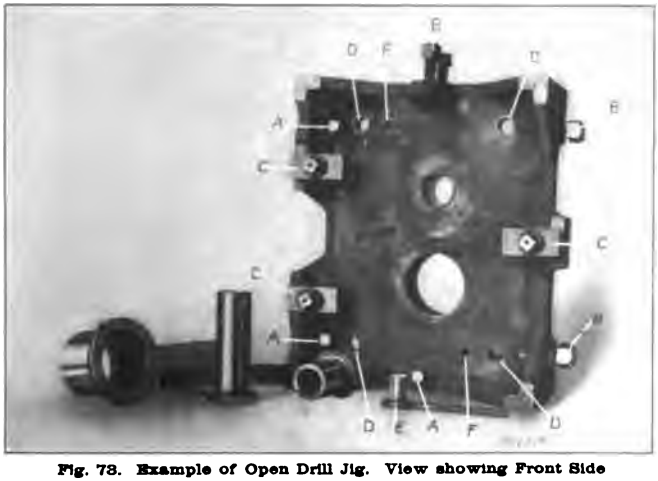


Fig. 73. Example of Open Drill Jig. View showing Front Side

straps are integral parts of the jig; at the same time, they are quickly and easily manipulated, and do not interfere with the rapid removal and insertion of the work. The strength and rigidity of the feet in proportion to the jig should be noted, this strength being obtained by giving proper shape to the feet, without using an unnecessary quantity of metal.

The jig in Fig. 73 is also designed to accommodate the component part of the work when it is being drilled. When this is done, the work is held on the back side of the jig, shown in Fig. 74. This side is also provided with feet, and has a finished pad against which the work is held. The locating pins extend clear through the central portion of the jig body, and, consequently, will locate the component

* MACHINERY, October. 1908.

part of the work in exactly the same position as the piece of work being drilled on the front side of the jig. The same clamping straps are used, the screws being simply put in from the opposite side into the same tapped holes as are used when clamping on the front side of the jig. The four holes *D* are guide holes for drilling the screw holes in the work, these being drilled the body size of the bolt in one part, and the tap drill size in the component part. The lining bushing in the holes *D* serves as a drill bushing for drilling the body size holes. The loose bushing *E*, Fig. 73, is used when drilling the tap holes in the component part, the inside diameter of this bushing being the tap drill size, and the outside diameter a good fit in the lining bushing. The two holes *F*, Fig. 74, are provided with drill bushings and serve as guides when drilling the dowel pin holes, which are drilled below size, leaving about 0.010 inch, and are reamed out

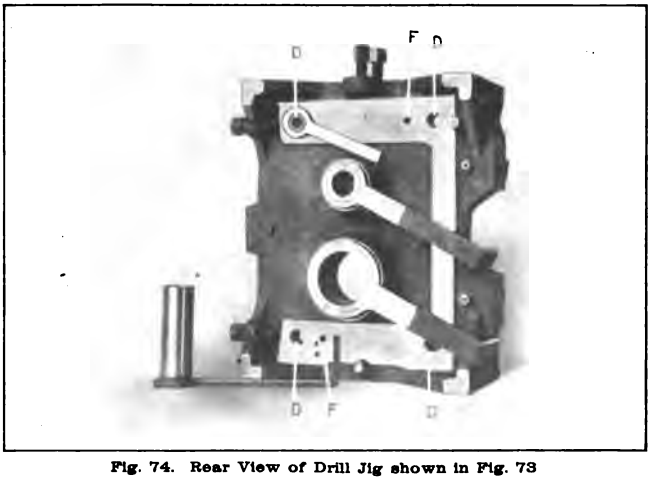


Fig. 74. Rear View of Drill Jig shown in Fig. 73

after the two component parts of the work are put together. The two holes shown in the middle of the jig in Fig. 73, and which are provided with lining bushings, and also with loose bushings, as shown inserted in Fig. 74, may be used for drilling and reaming the bearing holes for the shafts passing through the work. In this particular case, however, they are only used for rough-drilling the holes, to allow the boring-bars to pass through when finishing the work by boring in a special boring jig, after the two parts of the work have been screwed together.

The large bushings shown beside the jig in Fig. 73 are the loose bushings shown in place in Fig. 74. It will be noted that the bushings are provided with dogs for easy removal, as explained in Chapter II, and illustrated in Fig. 11. As the central portion of the jig body is rather thin, it will be noticed in Fig. 74 that the bosses for the central holes project outside of the jig body in order to give a long enough bearing to the bushings. This, of course, can be done

only when such a projection does not interfere with the work. The bosses, in this particular case, also serve another purpose. They make the jig "fool-proof," because the pieces drilled on the side of the jig shown in Fig. 73 cannot be put on the side shown in Fig. 74, the bosses preventing the piece from being placed in position in the jig.

Attention should be called to the simplicity of the design of this jig. It simply consists of a cast-iron plate, with finished seats, and feet projecting far enough to reach below the work when drilling, three dowel pins, set-screws for bringing the work up against the dowel pins, three clamps, and the necessary bushings. The heads of all the set-screws and bolts should, if possible, be made the same size, so that the same wrench may be used for tightening and unscrewing all of them. It can also be plainly seen from the half-tones that there

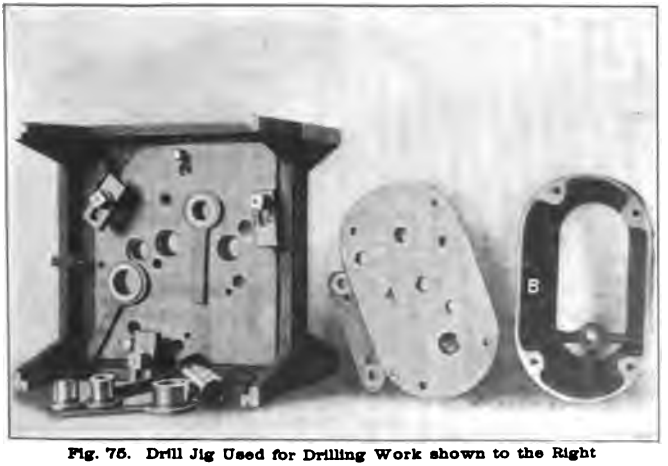


Fig. 75. Drill Jig Used for Drilling Work shown to the Right

are no unnecessarily finished surfaces on the jig, a matter which is highly important in economical production of tools.

Another example of an open drill jig, similar in design to the one just described, is shown in Fig. 75. The work to be drilled in this jig is shown at *A* and *B* at the right-hand side of the jig. In this case, the work is located from the half-circular ends. The pieces *A* and *B* are component parts, and when finished are screwed together. The piece *A* is located against three dowel pins, and pushed against them by set-screw *C*, and held in position by three clamping straps, as shown in Fig. 76. In this case, the straps are provided with oblong slots as indicated, and when the clamp screws are loosened, the clamps are simply pulled backward, permitting the insertion and removal of the work without interference. It would improve this clamping arrangement to place a stiff helical spring around the screws under each strap, so that the straps would be prevented from falling down to the bottom of the jig when the work is removed. At the same time this

would prevent the straps from swiveling around the screws when not clamped.

In Fig. 77, the part *B* in Fig. 75 is shown clamped in position for drilling, the opposite side of the jig being used for this purpose. In

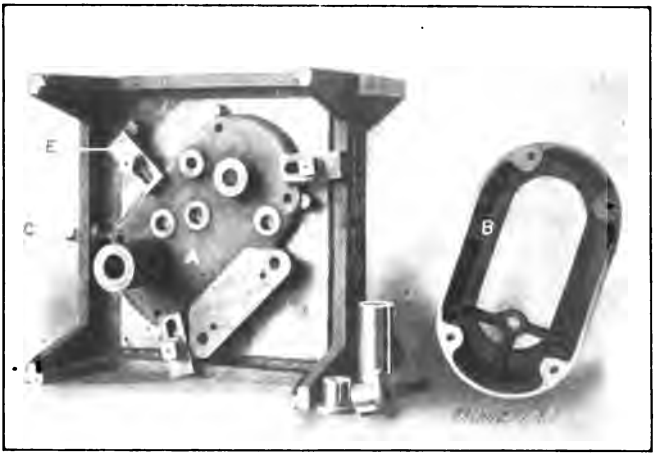


Fig. 76. Drill Jig shown in Fig. 75 with Work in Place

jig design of this kind it is necessary to provide some means so that the parts *A* and *B* will be placed each on the correct side of the jig, or, as said before, the jig should be made "fool-proof." In the present

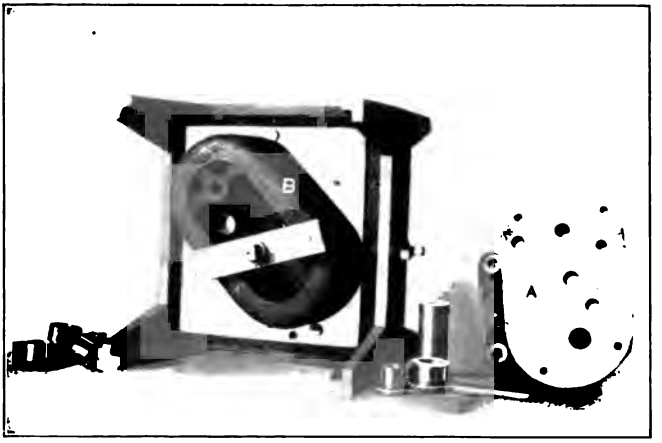


Fig. 77. Rear View of Drill Jig shown in Fig. 75, with Cover to be Drilled in Place

case, the parts cannot be exchanged and placed on the wrong side, because the cover or guard *B* cannot be held by the three straps in Fig. 76, because the screws for the straps are not long enough. On the other hand, the piece *A* could not be placed on the side shown in

Fig. 77, because the long bolt and strap used for clamping on this side would interfere with the work.

It may appear to be a fault in design that three straps are used to fasten the piece *A* in place, and only one is employed for holding piece *B*. This difference in clamping arrangement, however, is due to the different number and the different sizes of holes to be drilled in the different pieces. The holes in the piece *A* are larger and the number of holes is greater, and a heavier clamping arrangement is, therefore, required, inasmuch as the thrust on the former is correspondingly greater, the multiple spindle drill being used for drilling the holes. If each hole were drilled and reamed individually, the design of the jig could have been comparatively lighter.

In the design shown, the locating of each piece individually in any but the right way is also taken care of. The piece *A*, which is shown

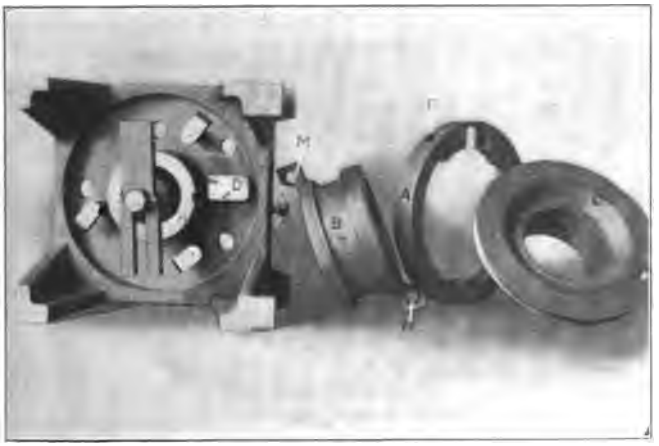


Fig. 78. Drill Jig for Parts of Friction Clutches shown at the Right

in place in the jig Fig. 76, could not be swung around into another position, because the strap and screw at *E* would interfere. For the same reason, the cover or guard *B* could not be located except in the right way. As shown in Fig. 77, the strap and screw would have to be detached from the jig in order to get the cover in place, if it were turned around. The locating pins for the work pass clear through the body of the jig, and are used for locating both pieces. The pieces are located diagonally in the jig, because, by doing so, it is possible to make the outside dimensions of the jig smaller. In this particular case the parts are located on the machine to which they belong, in a diagonal direction, so that the additional advantage is gained of being able to use the same dimensions for locating the jig holes as are used on the drawing for the machine details themselves. This tends to eliminate mistakes in making the jigs as well.

Sometimes, when more or less complicated mechanisms are composed of several parts fitted together and working in relation to each

other, as, for instance, friction clutches, one jig may be made to serve for drilling all the individual parts, by the addition of a few extra parts applied to the jig when different details of the work are being drilled. In Figs. 78, 79, and 80, such a case is illustrated. The pieces *A*, *B*, and *C*, in Fig. 78, are component parts of a friction clutch, and the jig in which these parts are being drilled, is shown in the same figure, to the left. Suppose now that we wish to drill the friction expansion ring *A*. The jig is bored out to fit the ring before it is split, and when it is only rough-turned, leaving a certain number of thousandths of an inch for finishing. The piece is located, as shown in Fig. 79, against the steel block *D* entering into the groove in the ring, and is then held by three hook-bolts, which simply are swung around when the ring is inserted or removed: The hook-bolts are tightened by nuts on the back side of the jig. Three holes marked

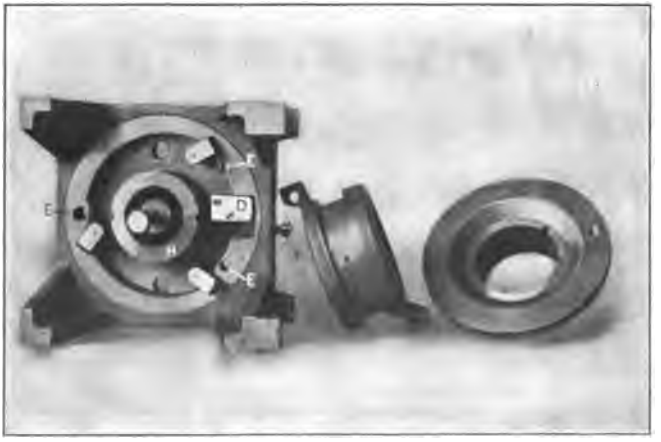


Fig. 79. Drill Jig shown in Fig. 78, with One of the Pieces in Place

E in Fig. 79, are drilled simultaneously in the multiple spindle drill, and the fourth hole *F* (see Fig. 78), is drilled by turning the jig on the side. The steel block *D*, Fig. 79, is hardened, and has a hole to guide the drill when passing through into the other side of the slot in the ring. The block is held in place by two screws and two dowel pins.

When drilling the holes in the lugs in the friction sleeve *B*, Fig. 78, the block *D* and the hook-bolts are removed. It may be mentioned here, although it is a small matter, that these parts should be tied together when removed, and there should be a specified place where all the parts belonging to a particular jig should be kept when not in use. The friction sleeve *B* fits over the collar *G*, Fig. 80. This collar is an extra piece, belonging to the jig, and used only when drilling the friction sleeve; it should be marked with instructions for what purpose it is used. The collar *G* fits over the projecting finished part *H* in the center of the jig, and is located in its right position by the keyways shown. The keyway in the friction sleeve *B*, which

must be cut and placed in the right relation to the projecting lugs before the piece can be drilled, locates the sleeve on the collar *G*, which is provided with a corresponding keyway. A flange on the collar *G*, as shown more plainly at *L* in Fig. 80, locates the friction sleeve at the right distance from the bottom of the jig, so that the holes will have a proper location sideways. Two collars, *G* and *L*, are used for the same piece *B*, this being necessary because the holes *M* and *M* in the projecting lugs shown in Fig. 78 are not placed in the same relation to the sides of the friction sleeve. The collars are marked to avoid mistakes, and corresponding marks on the jig provided so as to assure proper location. The friction sleeve is clamped in place by a strap which in this case does not form an integral part of the jig. This arrangement, however, is cheaper than it would have been to carry up two small projections on two sides of the jig, and

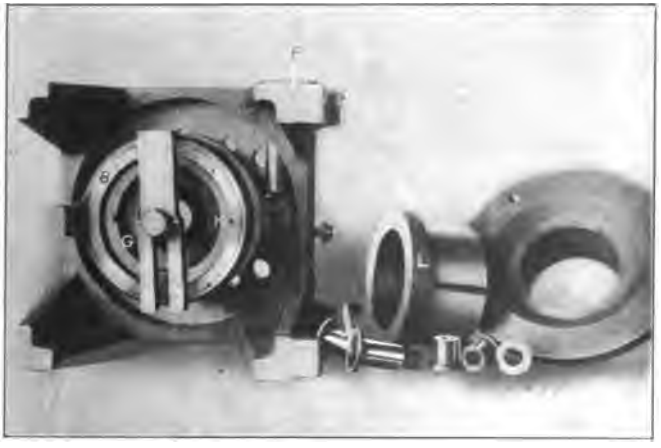


Fig. 80. Drill Jig shown in Fig. 78 used for Drilling Friction Sleeve

employ a swinging leaf and an eye-bolt, or some arrangement of this kind. Besides, the strap is rather large, and could not easily get lost. The jig necessarily has a number of loose parts, on account of being designed to accommodate different details of the friction clutch.

The friction disks *C*, in Fig. 78, when drilled, fit directly over the projecting finished part *H* of the jig, and are located on this projection by a square key. The work is brought up against the bottom of the jig and held in this position by the strap used in Fig. 80 for holding the friction sleeve. The bushings of different sizes shown in Fig. 80, are used for drilling the different sized holes in the different parts.

In all the various types of drill jigs described above, the thrust of the cutting tools is taken by the clamping arrangement. In many cases, however, no actual clamping arrangements are used, but the work itself takes the thrust of the cutting tools, and one depends entirely upon the locating means to hold the piece or jig in the right

position when performing the drilling operation. It may be well to add that large bushings ought to be marked with the size and kind of cutting tool for which they are intended; and the corresponding place in the jig body where they are to be used should be marked so that the right bushing can easily be placed in the right position.

A few more examples of open drill jig designs of various types may prove instructive. In Fig. 81 are shown two views of a jig for drilling two holes through the rim of a hand-wheel. To the left is shown the jig itself and to the right the jig with the hand-wheel mounted in place, ready for drilling. As shown, the hand-wheel is located on a stud through its bore, and clamped to the jig by passing a bolt through the stud, this bolt being provided with a split washer on the end. The split washer permits the easy removal of the hand-wheel when drilled, and the putting in place of another hand-wheel without

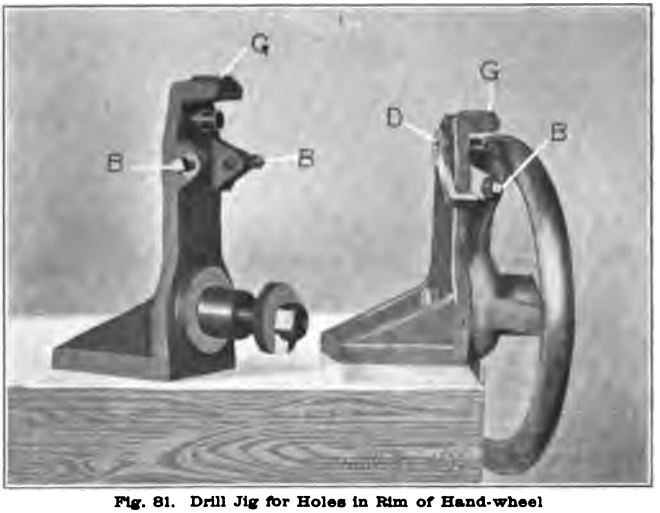


Fig. 81. Drill Jig for Holes in Rim of Hand-wheel

loss of time. The hand-wheel is located by two set-screws *B* passing through two lugs projecting on each side of a spoke in the hand-wheel, the set-screws *B* holding the hand-wheel in position while being drilled by clamping against the sides of the spoke. The jig is fastened on the edge of the drill press table, in a manner similar to that indicated in the half-tone, so that the table does not interfere with the wheel. The vertical hole, with the drill guided by bushing *G*, is now drilled in all the hand-wheels, this hole being drilled into a lug in the spoke held by the two set-screws *B*. When this hole is drilled, the jig is moved over to a horizontal drilling machine, and the hole *D* is drilled in all the hand-wheels, the jig being clamped to the table of this machine in a similar manner as on the drill press.

In Fig. 82, at *A*, an open drill jig of a type similar to those shown in Figs. 73 and 75, is shown. This jig, however, is provided with a V-block locating arrangement. An objectionable feature of this jig

is that the one clamping strap is placed in the center of the piece to be drilled. Should this piece be slender, it may cause it to bend, as there is no bearing surface under the work at the place where the clamp is located, for taking the thrust of the clamping pressure.

At *B* and *C* in the same engraving are shown the front and back views of a drill jig, where the front side *B* is used for drilling a small piece located and held in the jig as usual; and the back side *C*, which

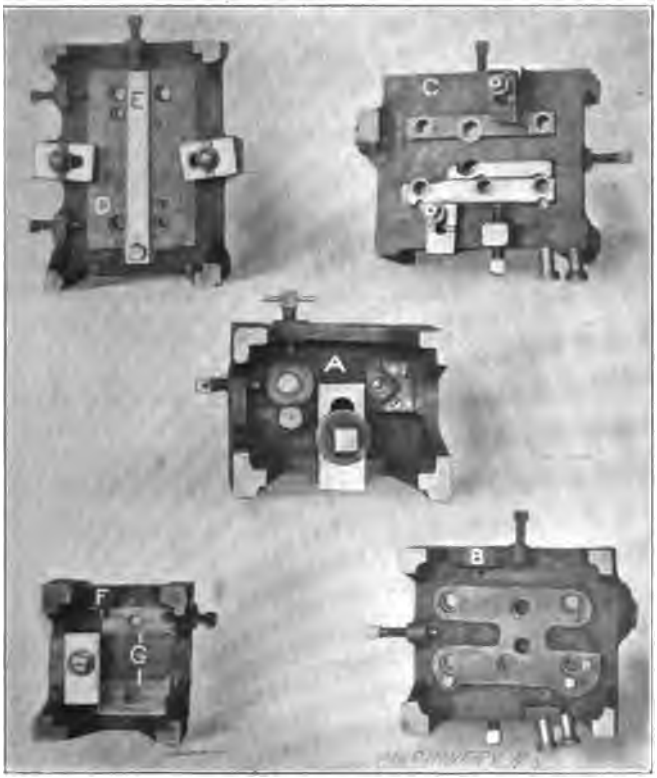


Fig. 82. Miscellaneous Examples of Open Drill Jigs

is not provided with feet, is located and applied directly on the work itself in the place where the loose piece is to be fastened, the work in this case being so large that it supports the jig, instead of the jig supporting the work.

At *D* in the same engraving is shown a jig for locating work by means of a tongue *E*. This tongue fits into a corresponding slot in the work. This means for locating the work was referred to more completely in connection with locating devices. Finally, at *F*, is shown a jig where the work is located by a slot *G* in the jig body, into which a corresponding tongue in the work fits.

CHAPTER VII

DESIGN OF CLOSED OR BOX JIGS*

In Chapters V and VI, the subject of the design of open drill jigs has been dealt with. In the present chapter it is proposed to outline the development of the design of closed or box jigs.

We will assume that the holes in a piece of work, as shown in Fig. 83, are to be drilled. Holes *A* are drilled straight through the work, while holes *B* and *C* are so-called "blind holes," drilled into the work from the opposite sides. As these holes must not be drilled through, it is evident that the work must be drilled from two sides, and the guiding bushings for the two blind holes must be put in opposite sides of the jig. The simplest form of jig for this work is shown in Fig. 84. The piece of work *D* is located between the two plates *E*, which form the jig, and which, if the jig be small, are made of machine steel and case-hardened. If the jig is large these plates

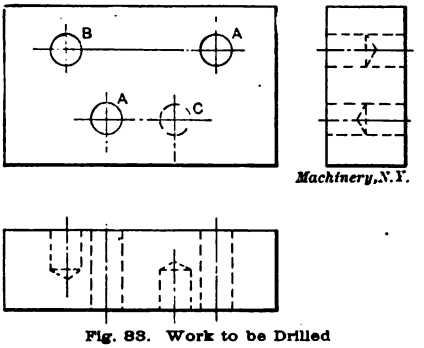


Fig. 83. Work to be Drilled

are made of cast iron. The work *D* is simply located by the outlines of the plates, which are made to the same dimensions, as regards width, as the work itself. The plates are held in position in relation to each other by the guiding dowel pins *F*. These pins are driven into the lower plate and have a sliding fit in the upper one. In some cases, blocks or lugs on one plate would be used to fit into a slot in the other plate instead of pins. These minor changes, of course, depend upon the nature of the work, the principle involved being that some means must be provided to prevent the two plates from shifting in relation to each other while drilling. The whole device is finally held together by clamps of suitable form. The holes *A* may be drilled from either side of the jig, as they pass clear through the work, and the guides for the drills for these holes may, therefore, be placed in either plate. Opposite the bushings in either plate a hole

* MACHINERY, November, 1908.

is drilled in the other plate for clearance for the drill when passing through, and for the escape of the chips.

The two plates should be marked with necessary general information regarding the tools to be used, the position of the plates, etc., to prevent mistakes by the operator. It is also an advantage, not to

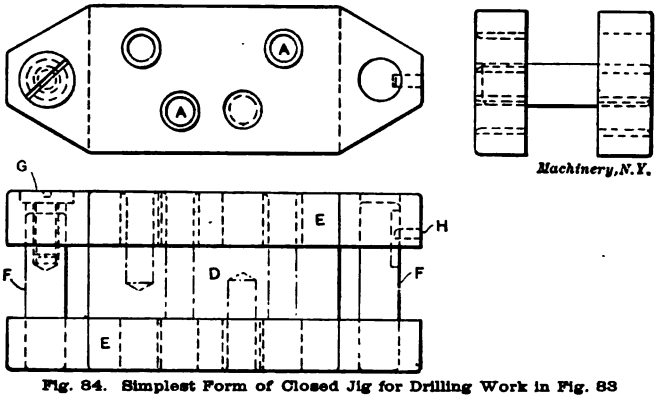


Fig. 84. Simplest Form of Closed Jig for Drilling Work in Fig. 83

say a necessity, to use some kind of connection between the plates in order to avoid such mistakes, as for instance, the placing of the upper plate in a reversed position, the wrong pins entering into the dowel pin holes. This, of course, would locate the holes in a faulty position. Besides, if the upper plate be entirely loose from the lower, it may

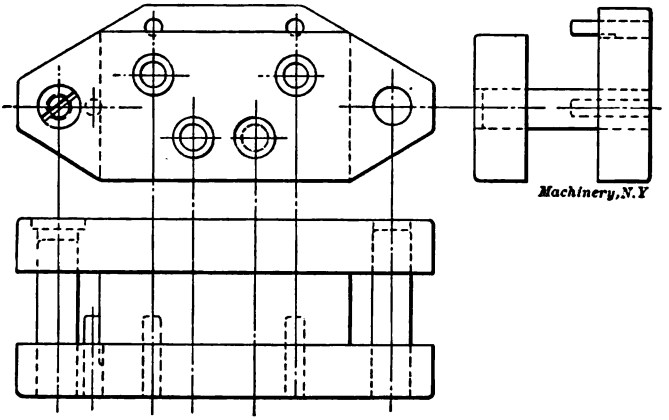


Fig. 85. Jig in Fig. 84 Improved by adding Locating Pins

drop off when the jig is stored, and get mixed up with other tools. Some means of holding the two parts together, even when not in use, or when not clamped down on the work, should therefore be provided. Such a means is employed in Fig. 84, where the screw *G* enters into the guiding dowel pin at the left, and holds the upper plate in place. A pin *H*, fitting into an elongated slot in the dowel pin as shown at

the left, could also be used instead of the screw. The design shown presents the very simplest form of box jig, consisting, as it does, of only two plates for holding the necessary guiding arrangements, and two pins or other means for locating the plates in relation to each other.

In manufacturing, where a great number of duplicate parts would be encountered, a jig designed in the simple manner shown in Fig. 84 would, however, be wholly inadequate. The simplest form of a jig that may be used in such a case would be one in which some kind of locating means is employed, as indicated in Fig. 85, where three pins are provided, two along the side of the work, and one for the end of the work, against which the work may be pushed, prior to the clamping together of the two jig plates. In this figure the jig bushings are not shown in the elevation and end view, in order to avoid confusion of lines. The next improvement to which this jig would be subject would be the adding of walls at the end of the jig and the screwing

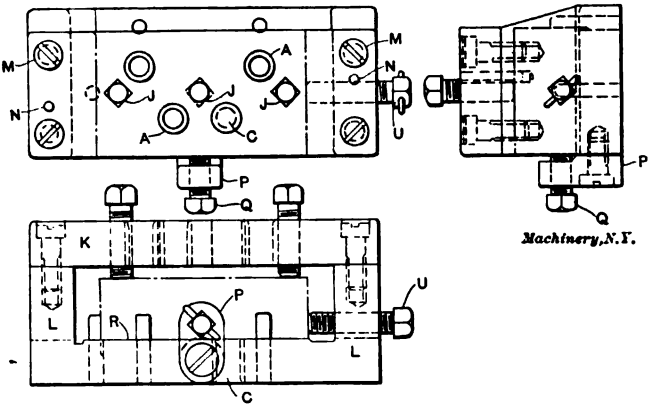


Fig. 86. Further Improvements in Jig, suiting it to Manufacturing Purposes

together of the upper and lower plate, the result being a jig as shown in Fig. 86. This design presents a more advanced style of closed jig—a type which could be recommended for manufacturing purposes. While the same fundamental principles are still in evidence, we have here a jig embodying most of the requirements necessary for rapid work. This design provides for integral clamping means within the jig itself, this being provided in this case by the screws *J*. The upper plate *K* is fastened to the walls of the lower plate *L* by four or more screws *M*, and two dowel pins *N*. The cover *K* could also be put on, as shown in Fig. 87, by making the two parts a good fit at *O*, one piece being tongued into the other. This gives greater rigidity to the jig. In this jig, also, solid locating lugs *F* are used instead of pins.

Referring again to Fig. 86, by providing a swinging arm *P* with a set-screw *Q*, the work can be taken out and can be inserted from the side of the jig, which will save making any provisions for

taking off or putting on the top cover for every piece being drilled. If there is enough clearance between the top cover and the piece being drilled, the screw *Q* could, of course, be mounted in a solid lug, but it would not be advantageous to have so large a space between the top plate and the work, as the drill would have to extend unguided for some distance before it would reach the work. The set-screws *Q*

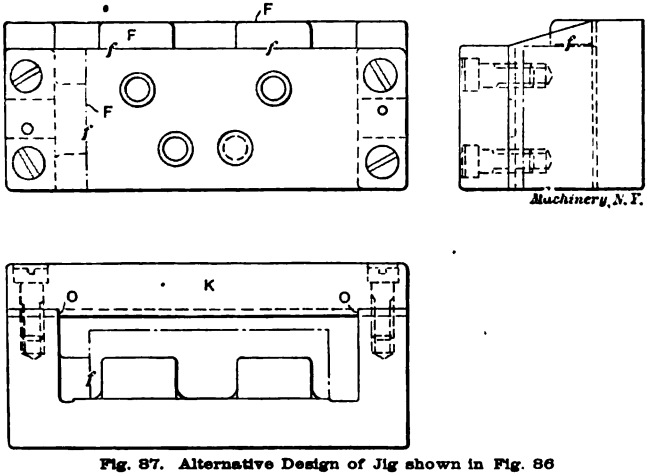


Fig. 87. Alternative Design of Jig shown in Fig. 86

and *U* hold the work against the locating points, and the set-screws *J* on the top of the jig, previously referred to, hold the work down on the finished pad *R* on the bottom plate. These screws also take the thrust when the hole *C* is drilled from the bottom side. It is rather immaterial on which side the bushings for guiding the drills for the

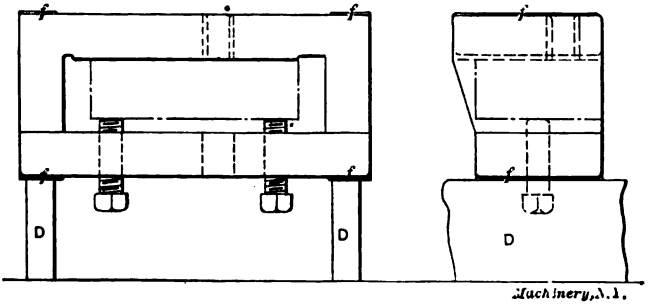


Fig. 88. Showing Use of Jig in Fig. 86 in Combination with Two Parallels

two holes *A* are placed, but by placing them in the cover rather than in the bottom plate, three out of the four bushings will be located in the top part, and when using a multiple spindle drill, the face *R* will take the greater thrust, which is better than to place the thrust on the binding screws *J*. In the designs in Figs. 86 and 87 the whole top and bottom face of the jig must be finished, or a strip marked *f* in

Fig. 88, at both ends of the top and bottom surfaces, must be provided, so that it can be finished, and the jig placed on parallels *D* as illustrated.

While the jig itself, developed so far, possesses most of the necessary points for rapid production and accurate work, the use of parallels, as indicated in Fig. 88, for supporting the jig when turned over so that the screw heads of the clamping screws point downward, is rather unhandy. Therefore, by adding feet to the jig, as shown in Fig. 89, the handling of the jig will be a great deal more convenient. The adding of the protruding handle *S* will still further increase the convenience of using the jig. The design in Fig. 89 also presents an improvement over that in Fig. 86 in that besides the adding of feet and handle, the leaf or strap *E* is used for holding screw *Q* instead of the arm *P*. This latter is more apt to bend if not very heavy, and would then bring the set-screw in an angle upwards, which would

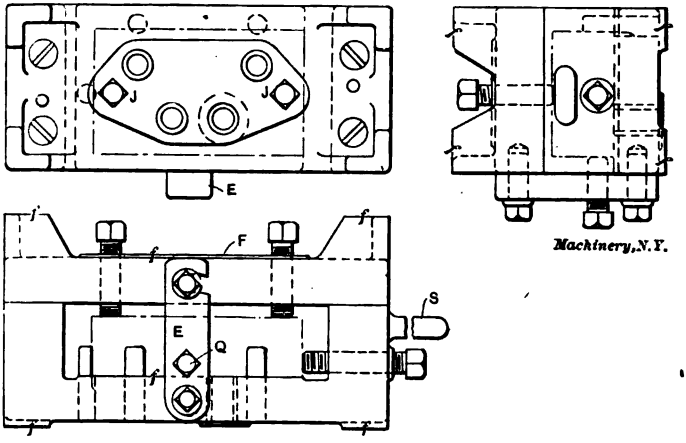


Fig. 89. Jig Improved by adding Feet opposite Faces containing Drill Bushings

have a tendency to tilt the work. The strap can be more safely relied upon to clamp the work squarely. To set-screws *J* are shown for holding the work in place. The number of these set-screws, of course, depends entirely upon the size of the work, and the size of the holes to be drilled. Sometimes one set-screw is quite sufficient, which, in this case, would be placed in the center, as indicated by the dotted lines in Fig. 86.

The type of jig shown in Fig. 89 now possesses all the features generally required for a good jig, and presents a type which is largely used in manufacturing plants, particularly for fairly heavy work. The jig shown in Fig. 90, however, represents another type, somewhat different from the jig in Fig. 89. The jig in Fig. 89 is composed of two large separate pieces, which, for large jigs, means two separate castings, involving some extra expense in the pattern-shop and foundry. The reason for making the jig in two parts, instead of casting it in one, is because it makes it more convenient when machining the

jig. The locating points, however, are somewhat hidden from view when the piece is inserted. The jig shown in Fig. 90 consists of only one casting *L*, provided with feet, and resembles an open drill jig. The work is located in a manner similar to that already described, and the leaf *D*, wide enough to take in all the bushings except the one for the hole that must be drilled from the opposite side, is fitted across the jig and given a good bearing between the lugs in the jig wall. It swings around the pin *E*, and is held down by the eye-bolt *F* with a nut and washer. Sometimes a wing-nut is handier than a hexagon nut. Care should be taken that the feet reach below the top of the nut and screw. The set-screw *G* holds the work down, and takes the thrust when the hole from the bottom side is drilled. The three holes *AA* and *B* are drilled from the top so that the thrust of

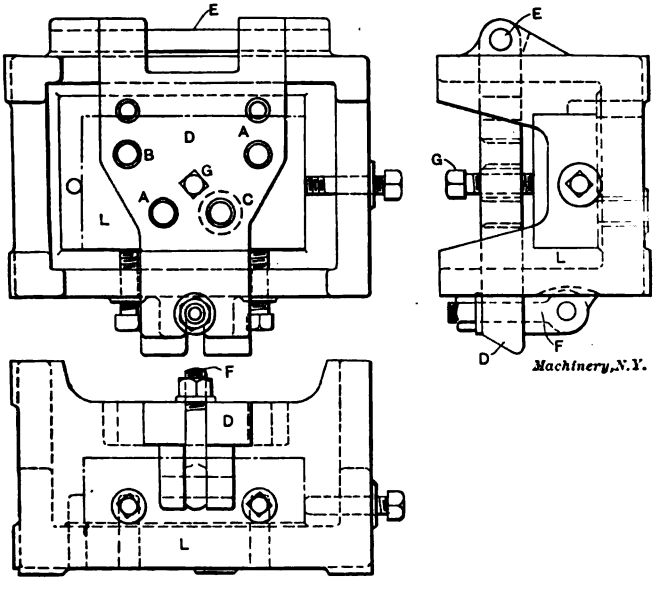
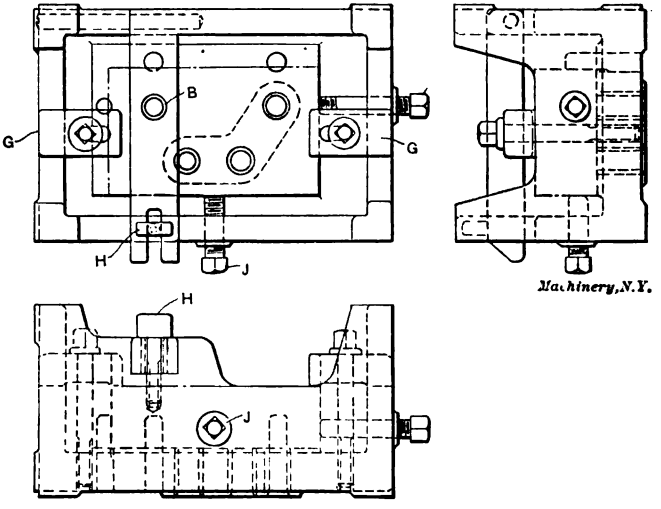


Fig. 90. Alternative Design of Jig in Fig. 89

the drilling these three holes will be taken by the bottom of the jig body *L*. If one set-screw *G* is not sufficient for holding the work in place, the leaf may be made wider so as to accommodate more binding screws.

It should be mentioned here, however, that it is an objectionable feature to place the clamping screws in the bushing plate. If the leaf has not a perfect fit in its seats and on the swiveling pin, the screws will tilt the leaf one way or another, and thus cause the bushings to stand at an angle with the work, producing faulty results. In order to avoid this objectionable feature, a further improvement on the jig, indicated in Fig. 91, is proposed. In the jig body, the locating points and the set-screws which hold the work against the locat-

ing pins are placed so that they will not interfere with two straps *G*, which are provided with elongated slots, and hold the work securely in place, also sustaining the thrust from the cutting tools. These straps should be heavily designed, in order to be able to take the thrust of the multiple spindle drill, because in this case all the bushings except the one for hole *B* are placed in the bottom of the jig body. The leaf is made narrower and is not as heavy as the one shown in Fig. 90, because it does not, in this case, take any thrust when drilling, and simply serves the purpose of holding the bushing for hole *B*. The leaves and loose bushing plates for jigs of this kind are generally made of machine steel, but for larger sized jigs they may be made of cast iron. The leaf in Fig. 91 is simply held down by the thumb-screw *H* of a type as shown in Fig. 48 in Chapter IV.



Machinery, N.Y.

Fig. 91. Jig where Thrust of Drilling Operation is taken by Clamps

If the hole *B* should be near to one wall of the jig, it may not be necessary to have a leaf, but the jig casting may be made with a projecting lug *D*, as shown in Fig. 92, the jig otherwise being of the same type as the one illustrated in Fig. 91. The projecting part *D*, Fig. 92, is strengthened, when necessary, by a rib *E*, as indicated. Care must be taken that there is sufficient clearance for the piece to be inserted and removed. Once in a while it happens, even with fairly good jig designers, that an otherwise well-designed jig with good locating, clamping, and guiding arrangements, is rendered useless for the simple reason that there is not enough clearance to allow the insertion of the work. The jig shown in Fig. 92 resembles, in reality, an open jig more than a closed jig.

Fig. 93 shows the same jig as before, but with the additional feature of permitting a hole in the work to be drilled from the end and side as indicated, the bushings *E* and *F* being added for this purpose. It will be noticed that the bushings in this case extend through the

jig wall for some distance, in order to guide the drill closely to the work. Bosses may also be cast on the jig body, as indicated by the dotted lines, to give a longer bearing for the bushings.

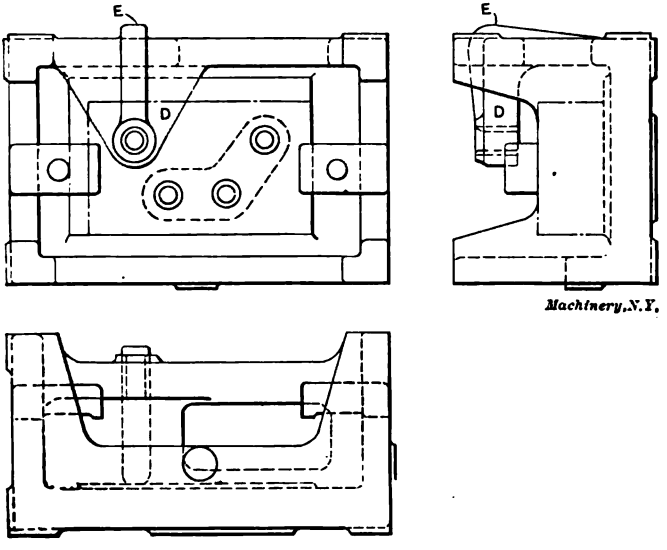


Fig. 92. Modification of Jig in Fig. 91, which practically brings it into the Class of Open Drill Jigs

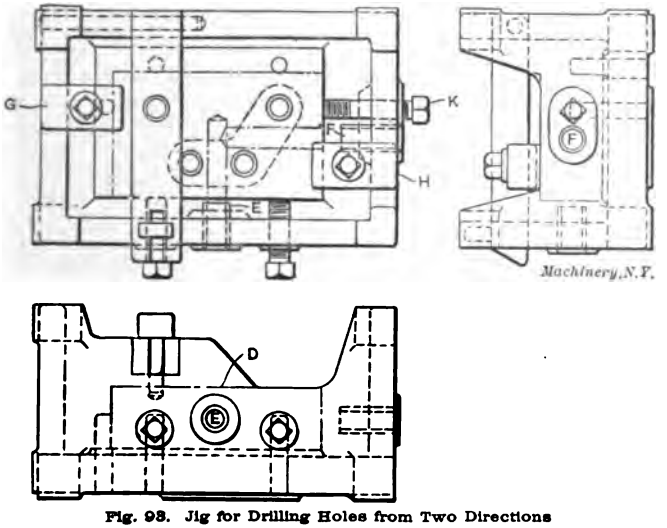


Fig. 93. Jig for Drilling Holes from Two Directions

Feet or lugs are cast and finished on the sides of the jig opposite the bushings, so that the jig can be placed conveniently on the drill press table for drilling in any direction. It will be noticed that when drilling the holes from the bushings *E* and *F*, the thrust is

taken by the stationary locating pins. It is objectionable to use set-screws to take the thrust, although in some cases it is necessary to do so. When designing a jig of this type, care must be taken that strapping arrangements and locating points are placed so that they, in no way, will interfere with the cutting tools or guiding means. In this case the strap *H* is moved over to one side in order to give room for the bushings *F* and the set-screw *K*. Strap *G* should then be moved also, because moving the two straps in opposite directions still gives them a balanced clamping action on the work. If the strap *G* had been left in place, with the strap *H* moved sideways, there would have been some tendency to tilt the work.

Sometimes one hole in the work comes at an angle with the faces of the work. In such a case the jig must be made along the lines

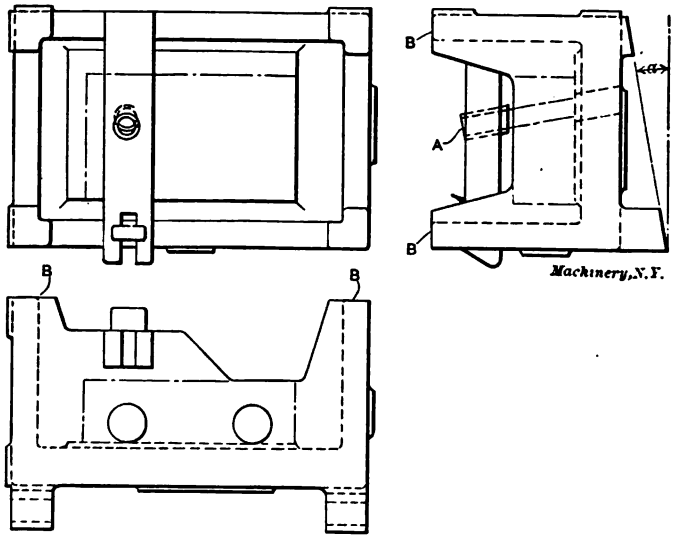


Fig. 94. Jig for Drilling Holes at an Angle

indicated in Fig. 94, the feet on the sides opposite to where the drill bushings are placed being planed so that their faces will be perpendicular to the axis through the hole *A*. This will, in no way, interfere with the drilling of holes which are perpendicular to the faces of the work, as these can be drilled from the opposite side of the work, the jig then resting on the feet *B*. Should it, however, be necessary to drill one hole at an angle, and other holes perpendicular to the face of the work from the same side, an arrangement as shown in Fig. 95 would be used. The jig here is made in the same manner as the jig shown in Fig. 93, with the difference that a bushing *A* is placed at the required angle. It will be seen, however, that as the other holes drilled from the same side must be drilled perpendicularly to the faces of the work, it would not be of advantage to plane the feet so that the hole *A* could be drilled in the manner previously

shown in Fig. 94. Therefore the feet are left to suit the perpendicular holes, and the separate base bracket *B*, Fig. 95, is used to hold the jig in the desired inclined position when the hole *A* is drilled.

Stand *B* in Fig. 95 is very suitable for this special work. It will be noticed that it is made up as light as possible, being cored at the center,

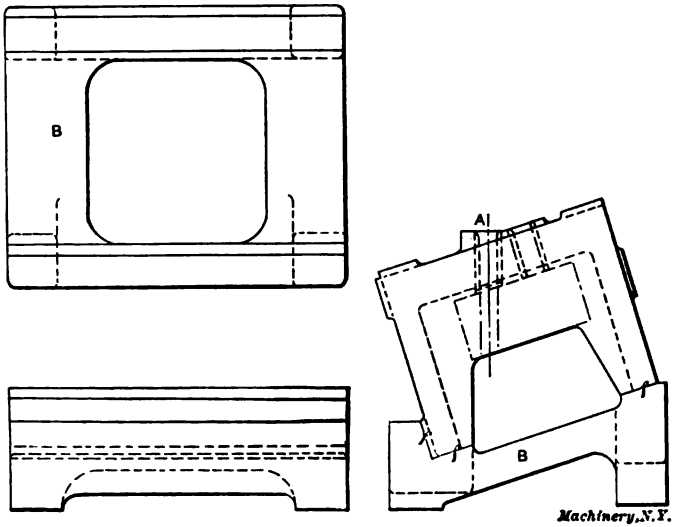


Fig. 95. Jig and Stand for Drilling Holes at an Angle

so as to remove superfluous metal. These stands are sometimes provided with a clamping device for holding the jig to the stand. Special stands are not only used for drilling holes at angles with the remaining holes to be drilled, but sometimes special stands are made to

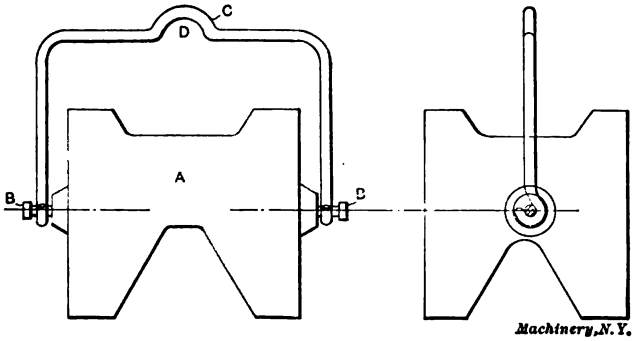


Fig. 96. Device for Turning over and Handling Heavy Jigs

suit the jig in cases where it would be inconvenient to provide the jig with feet, finished bosses or lugs, for resting directly on the drill press table.

When a jig of large dimensions is to be turned over, either for the insertion or removal of the work, or for drilling holes from opposite

sides, a helper will have to be called upon to assist the operator. The disadvantage of this is readily seen. In cases where the use of a crane or hoist can be obtained, it is very satisfactory to have a special device attached to the jig for turning it over. Fig. 96 shows such an arrangement. In this engraving, *A* represents the jig which is to be turned over. The two studs *B* are driven into the jig in convenient places, as near as possible in line with a gravity axis. These studs then rest in the yoke *C*, which is lifted by the crane hook placed at *D*. The jig, when lifted off the table, can then easily be swung around. The yoke is made simply out of round machine steel.

Comparing what has been said above with the outline of the development of open jigs in Chapter V, it will be seen that the principles involved are exactly the same, and that the development of jigs for various purposes is simply the application of these principles to the work in hand, with an appropriate amount of common sense. The previous statements may be considered the A, B, C of jig making, and contain, of necessity, only the main principles on which the jig design is based.

CHAPTER VIII

EXAMPLES OF CLOSED OR BOX JIGS*

In the previous chapter, the development of a closed or box jig was treated. In the present chapter a number of examples of closed jig designs will be shown and described. There is, however, no distinct division line between open and closed drill jigs, so that in many cases it is rather inconsistent to attempt to make any such distinction.

In Fig. 97, for instance, is shown a box jig which looks like a typical open jig. The jig body *A* is made in one solid piece, cored out as shown, in order to make it lighter. The piece to be drilled, *B*, shown inserted in the jig, has all its holes drilled in this jig, the

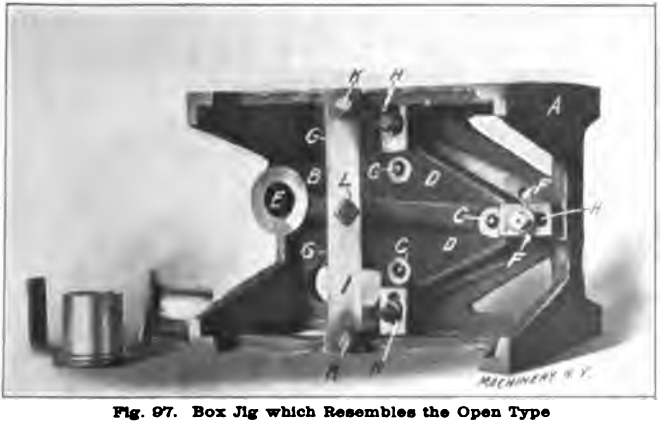


Fig. 97. Box Jig which Resembles the Open Type

holes being the screw holes *C*, the dowel pin holes *D*, and the large bearing hole *E*. The bosses of the three screw holes *C* are also faced on the top, and the bearing is faced on both sides while the work is held in the jig. The work is located against two dowel pins driven into the holes *F*, and against two lugs at *G*, not visible in the engraving, located on either side of the work. In these lugs are placed set-screws or adjustable sliding points such as described in Chapter III. It may seem incorrect not to locate the bracket in regard to the hole *E* for the bearing, so as to be sure to bring the hole concentric with the outside of the boss. This ordinarily is a good rule to follow, but in this particular case it is essential that the screw holes be placed in a certain relation to the outline of the bracket in order to permit this to match up with the pad on the machine on which the bracket is used. Brackets of this shape may be cast very

*MACHINERY, December, 1908.

uniformly, so that locating them in the manner described will not seriously interfere with drilling the hole *E* approximately in the center of its boss. The work is firmly held in the jig by the three straps *H*, care being taken in designing the jig that these straps are placed so they will not interfere with the facing tools.

The swinging strap *I*, which really is the only thing that makes this jig a closed jig, serves the sole purpose of taking the thrust of the heavy cutting tools when drilling the hole *E* and of steadying the work when facing off the two ends of the hub. The two collar-head screws *K* hold the strap to the jig body and the set-screw *L* bears against the work. This strap is easily swung out of the way

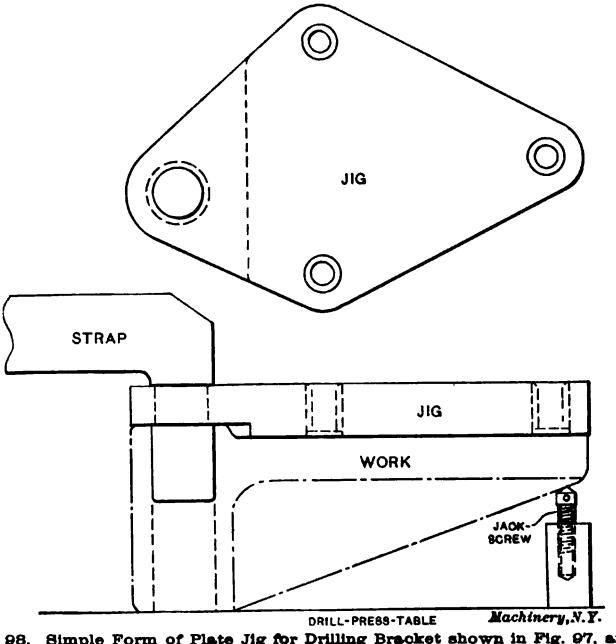


Fig. 98. Simple Form of Plate Jig for Drilling Bracket shown in Fig. 97, after Hole E has been bored in the Lathe

simply by loosening one of the collar-head screws, a slot being milled at one end of the strap to permit this. Stationary bushings are used for the screw hole and dowel holes, but for the bearing hole *E* three loose bushings and a lining bushing are employed. The hole *E* is first opened up by a small twist drill, which makes the work considerably easier for the so-called rose-bit drill. The latter drill leaves 1/16 inch of stock for the rose reamer to remove, which produces a very smooth, straight and concentric hole. The last operation is the facing of the holes. The holes just drilled are now used to guide the pilots of the facing tools, and as the operation is performed while the work is held in the jig, it is important that the locating or strapping arrangements should not be in the way.

In connection with the opening up of a hole with a smaller drill, it may be mentioned that it is not only for large holes that this method of procedure will save time, but the method is a time-saving one also for smaller holes, down to ¼ inch in diameter when drilled in steel.

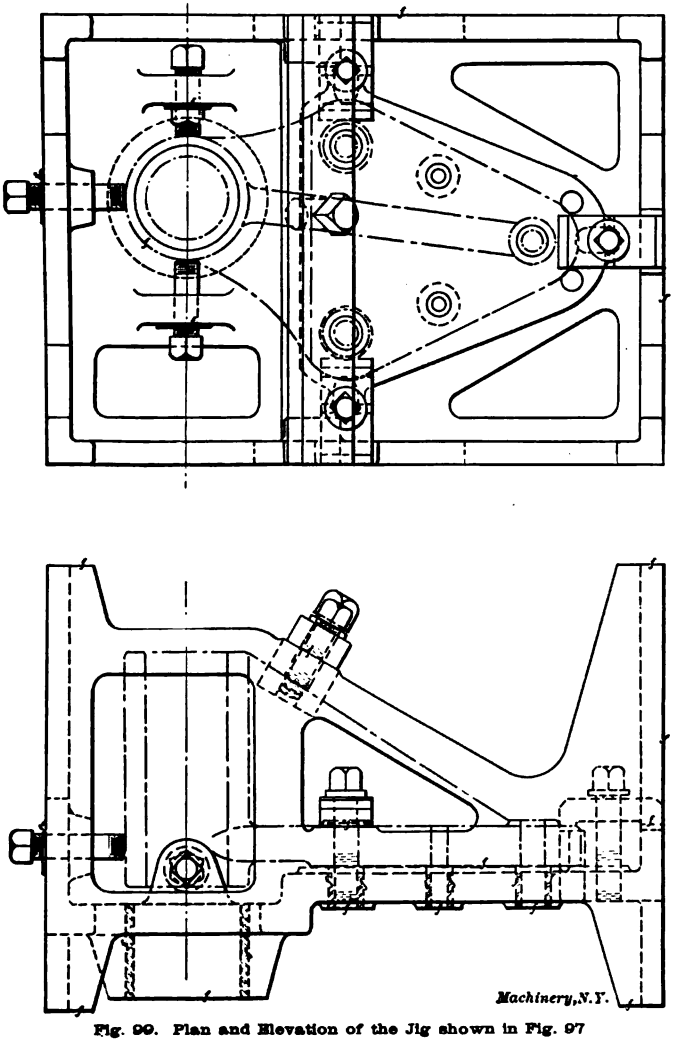


Fig. 99. Plan and Elevation of the Jig shown in Fig. 97

The use of lubrication in jigs is a very important item, the most common lubricant being oil or vaseline, but also soap solution is used. The objection to the latter is that unless the machine and tools are carefully cleaned, it is likely to cause rusting. Using a lubricant freely will save the guiding arrangements, such as the drill bushings, the pilots on counterbores, etc., to a great extent.

The jig in Fig. 97 is shown in Fig. 99, and a clear idea of the design of the jig will be had by studying this line engraving. The bracket *B*, in Fig. 97, could have been drilled in a different way than described, which will sometimes be an advantage. It could be held in a chuck, and the hole *E* reamed and faced in a lathe, which would insure that the hole would be perfectly central with the outside of the boss. Then a jig could be designed, locating the work by a stud entering in hole *E*, as indicated in Fig. 98, additional dowel pins and set-screws being used for locating the piece sidewise. The whole arrangement could be held down to the table by a strap and bolt, a jack-screw supporting it at the overhanging end.

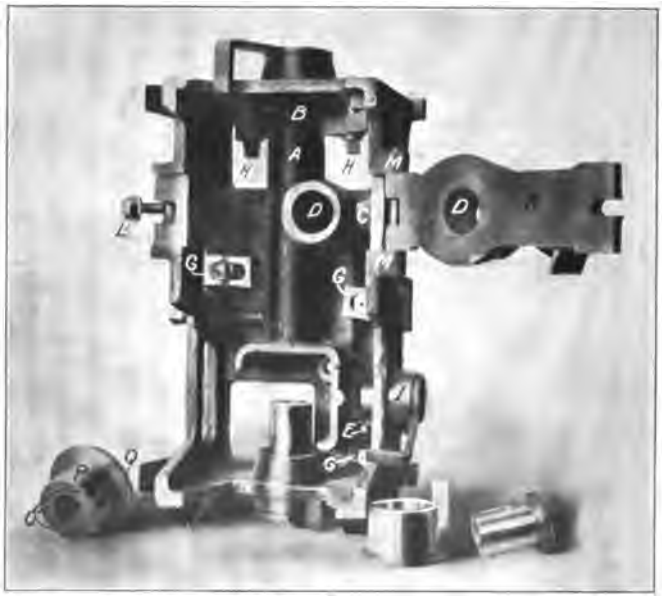


Fig. 100. Box Jig for Casing drilled from Five Directions

Fig. 100 shows another jig of the closed type, with the work inserted. The piece *A* is a casing, and the holes to be drilled vary greatly in size. The casing rests on the flat, finished bottom surface of the jig and is brought up squarely against a finished pad at *B*. It further locates against the finished lug *C* in order to insure getting the proper amount of metal around the hole *D*. At the bottom it is located against the sliding point *E*, the latter being adjustable because the location of the work is determined by the other locating points and surfaces. The work is held against the locating points by the long set-screws shown to the left. This clamping arrangement, however, is not to be recommended because this screw must be screwed back a considerable distance in order to permit insertion and removal of the work. An eye-bolt used in the manner previously described in Chapter IV of Part I would have given better service. The three

straps *G* hold the work against the bottom surface, and the two straps *H* hold it against the finished surface at *B*. There is not a long finished hole through the casting, as would be assumed from its appearance, but simply a short bearing at each end, the remaining part of the hole being cored out. For this reason the hole is drilled and reamed instead of being bored out, as the latter operation would be a slower one. Although the two short bearings are somewhat far apart, the guiding bushings come so close to these bearings that the alignment can be made very good. The screw holes and dowel pin holes at

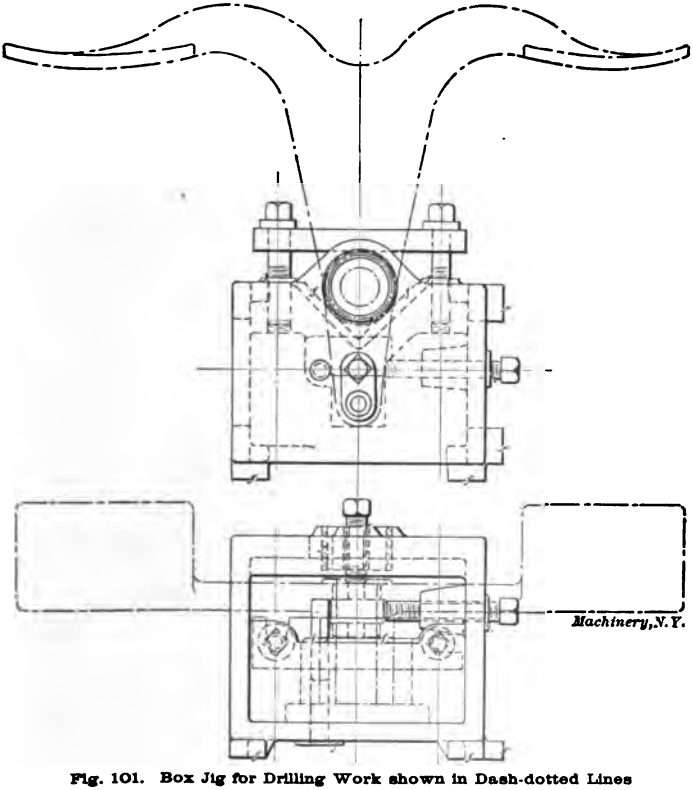


Fig. 101. Box Jig for Drilling Work shown in Dash-dotted Lines

the bottom of the casing are not shown in the half-tone, as the inserted casing is not yet drilled. The hole drilled from bushing *I* is a rather important hole, and the bushing requires a long bearing in order to guide the drills straight when drilling. When this jig was made, the projecting lug which was provided solid with the jig body, to give a bearing to the jig bushing, came so much out of the way in the rough casting for the jig that half of the lining bushing would have been exposed. It was therefore planed off and a bushing of the type shown in Fig. 9, Chapter II, inserted instead, in order to provide for a long bearing.

Leaf *K*, which carries the bushings for drilling the hole *D*, fits into a slot planed out in the jig body and is held down by the eye-bolt *L*. Two lugs *M* are provided on the main casting for holding the pin on which the leaf swivels, the construction being of the same type as illustrated in Fig. 50, Chapter IV. Around the hole *D* there are three small tap holes *O* which are drilled by the guiding afforded by the bushing *P*, which is made of cast iron and provided with small steel bushings placed inside as illustrated in Fig. 16, Chapter II. In the bushing *P* is another hole *Q* which fits over a pin located in the top of the leaf and which insures that the three screw holes will come in the right position. It should be noted that large portions of the jig body are cored out at top and bottom in order to

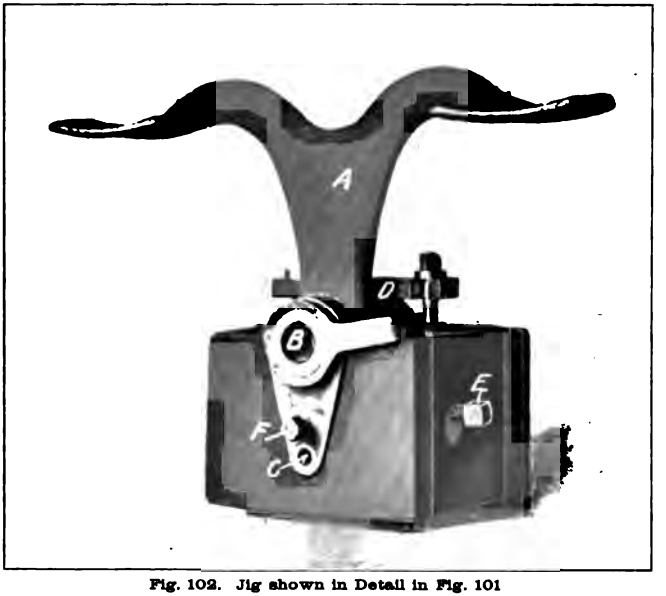


Fig. 102. Jig shown in Detail in Fig. 101

make it light and easy to handle. Of course some metal is also saved by the construction of jigs in this manner, but comparing the price of cast iron with the total price of a finished jig of this type, the saving in this respect is so insignificant that it is not worth while mentioning. The leaf *K* is also made of cast iron, being of particularly large size, and it is planed at the places where it has a bearing on the jig body.

Fig. 102 shows a closed jig about which there can be no doubt but that it should be classified as a box jig. The piece of work drilled, the foot trip *A*, has two holes *B* and *C* which are drilled in this jig. The cylindrical hub of the work is located against V-blocks and held in place by a swinging strap *D*. The work is further located against a stop pin placed opposite the set-screw *E*. The trip is located sidewise

by being brought against another stop by the set-screw *F*. One-quarter of a turn of the collar-head screw on the top of the jig releases the swinging strap which is then turned out of the way; this permits the trip to be removed and another to be inserted. Half a turn or less of the set-screws is enough to release and clamp the work against the stops mentioned. A line engraving of this jig is shown

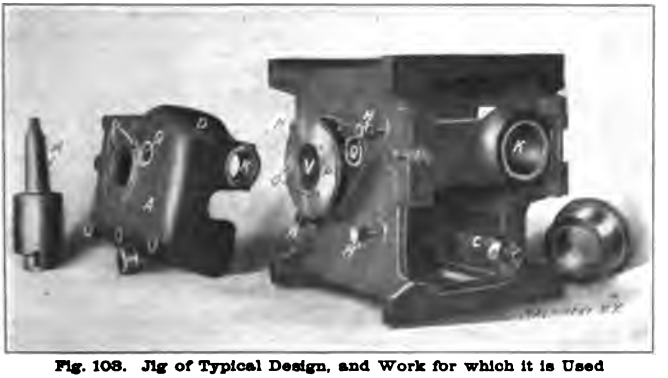


Fig. 103. Jig of Typical Design, and Work for which it is Used

in Fig. 101 which gives a better idea of some of the details of the construction.

In Figs. 103 and 104 are shown two views of another type of closed drill jig. The work *A*, to be drilled, is shown at the left in both illustrations, and consists of a special lathe apron with large bearing holes, screw holes, and dowel pin holes to be drilled. The apron is located

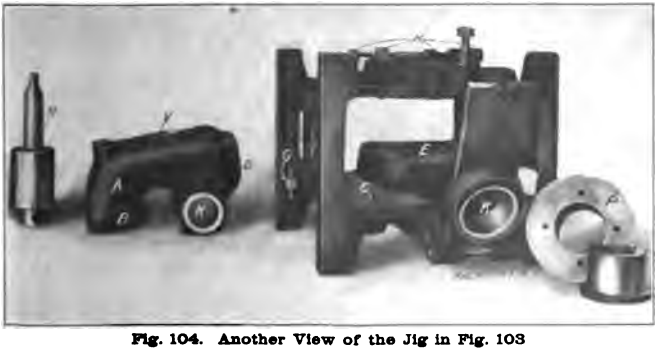
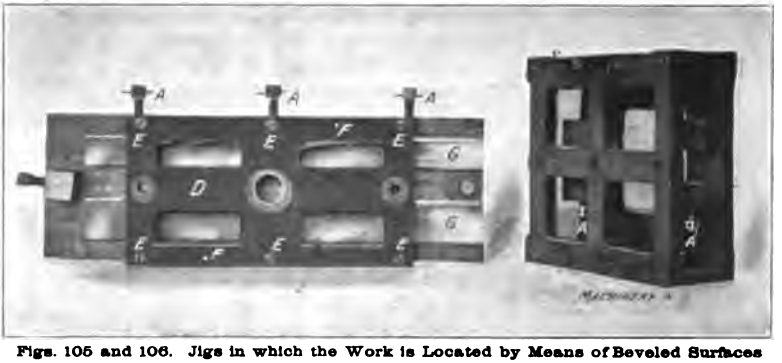


Fig. 104. Another View of the Jig in Fig. 103

in the jig body in the same manner as it is located on the lathe carriage, in this case by a tongue which may be seen at *B* in Fig. 104. This tongue fits into the slot *C* in the jig, care being taken in the construction of the jig that the slot is made deep enough to prevent the tongue from bearing in the bottom of the slot. A good solid bearing should be provided, however, for the finished surface on both sides of the tongue. The surface *D* should also have a solid bearing on the

surface *H* in the jig, the difference in height between the two bearing surfaces in the jig being exactly the same as between the two bearing surfaces on the lathe carriage where the lathe apron is to be fitted. The work is brought up against, and further located by, a dowel pin at the further end of the slot, by the set-screw in the block *F*, Fig. 103. As



Figs. 105 and 106. Jigs in which the Work is Located by Means of Beveled Surfaces

it is rather difficult to get the tongues on all the pieces exactly the correct width for a good fit in the slot, the latter is sometimes planed a little wider and the tongue is brought up against one side of the slot by set-screws. In the case in hand, a few thousandths inch clearance is provided in the slot and the set-screw *G* in Fig. 104 is used

Fig. 107. Jig for Drilling Holes at other than 90-degree Angles

for bringing the work against the further edge which stands in correct relation to the holes to be drilled. The apron is held down against the bottom surface of the jig by four heavy set-screws *H*.

It will be noticed that the jig is open right through the sides in order to facilitate the finishing of the pads at the ends of the work,

and a swinging leaf like the one previously described, reaches across one side for holding the lining and loose bushings for the hole *K* which is drilled and rose-reamed in the usual way. The large hole *V*, Fig. 103, is bored out with a special boring tool *M*, as there are no standard drills obtainable for this large size of hole. This special boring tool is guided by a cast iron bushing which fits into the lining bushing; it is provided with two cutters, one for roughing and one for finishing. The small screw holes *O* around the large hole *V* are drilled from the bushing *P*. For drilling the rest of the holes, except the hole *Q*, stationary bushings are used. The screw holes ought to be drilled simultaneously in a multiple spindle drill. The jig is provided with feet and cored out in convenient places in order to make it as light as possible to handle. Lugs project wherever necessary to give ample

Fig. 108. Jig in Fig. 107 in Position for Drilling Holes at an Oblique Angle with Jig Base

bearings to the lining bushings and, in turn, to the loose guiding bushings.

Figs. 105 and 106 show two closed jigs made up of two main parts which are planed and assembled by screws and dowels as indicated, the reason for making the jigs in this way being the ease of planing the bottom section. The work drilled in these jigs, some special slides, is located by the dove-tail and held up against one dove-tail side by set-screws *A*, as shown in both illustrations. In Fig. 105 the work is located endwise against a dowel pin and is held up against this stop by a set-screw through the block shown to the left. This block must be taken out when the slide is inserted, this being the reason why a lug cast directly in place, through which the set-screw could pass, is not used. The top plate *D* is held down on the main body by six fillister-head screws *E*, and two dowel pins *F* prevent it from shifting. No clamping arrangements, except the set-screws *A*, are necessary. The

holes being drilled from the top, the main body of the jig takes the thrust. These jigs are also used in multiple spindle drills.

One objectionable feature of the jig in Fig. 106 is that set-screws *A* are difficult of access. There are, therefore, holes piercing the heads of the set-screws in two directions in order to allow a pin to be used when tightening the screws. A better idea, however, is to have the screw heads extend out through the wall, and if this is solid, to have cored or drilled holes through which the heads of the screws may pass.

In Fig. 107 is another closed drill jig in which the work is located against the finished seats and held down by the set-screws *A* in the straps *B*. All the holes, except the holes marked *C*, are drilled in the usual manner, the jig standing on its own feet, but when drilling the holes *C*, which come on an angle, the special stand *D* is employed which brings the holes in the right position for drilling, as illustrated in Fig. 108. If only the holes *C* were to be drilled, the feet on the side opposite the guiding bushing for these holes could have been planed off, so that they would have been in a plan perpendicular to the axis of the holes. This last jig has a peculiar appearance on account of the end walls coming up square, as shown in the illustrations, but this design was adopted only to simplify matters for the patternmaker, it being easier to make the pattern this way.

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